

Final Report for

Grant NAG8-1022

An Analysis of BATSE Gamma-ray Burst Time Profiles

John Patrick Lestrade

Mississippi State University

Principal Investigator

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by

John Patrick Lestrade
Associate Professor of Physics and Astronomy
Mississippi State University
Mississippi State, Mississippi, 39762

Abstract

This proposal requested funding to study the time profiles of gamma-ray bursts (grb) returned by the Burst And Transient Source Experiment (BATSE) on board the Compton Gamma-Ray Observatory.

1. Introduction.

Our work during the time of this contract was divided into three categories: 1) Variability analysis of GRB time profiles, 2) GRB duration measurements for the 3B catalog, and 3) fractal analysis of GRB time profiles.

1A. Variability

Our work in the area of GRB profile variability concentrated on calculating a parameter that measures the amount of “structure” in a profile. Our initial attempt calculated this parameter by applying an algorithm similar to the standard ‘run’ test (Eadie, 1957). The algorithm is based on runs of monotonically increasing (or decreasing) bin-to-bin differences. The more structure there is in a profile, the more often we see a monotonic run up or down.

Intuitively, we felt that there was a non-uniformity in the distribution of ‘spikiness’. We hoped that a structure parameter would reveal an interesting non-uniformity. However, applying this algorithm to over a hundred profiles showed no clustering of structure (Lestrade et al., 1994; attached herein). We are now turning our attention to fractal algorithms (see 1C below) in the hope that they may provide a different view.

1B. Duration Measurements

The discovery by the BATSE team of a bimodality in the durations of GRB was greeted with much excitement by the GRB community. (Since this discovery did not reveal anything significant about the true nature of GRB's, this excitement shows how frustrating and elusive the study of GRB has been!) As part of our assignment, we agreed to measure the burst durations for the 3B catalog. This took several months, but the results were very satisfying as our measurements revealed the same bimodality. Sample pages of output from our duration measuring program are included in this report as Figures 1-3. A list of the 403 GRB's measured appears in Table 1. Table 2 presents a list of the 48 GRB's for which the duration was not obtainable from the data. (These non-measurable durations were usually due to data gaps – a problem that was caused by the failure of the onboard tape recorders and which has been partially offset by improved real-time data transmission.)

Figures 4 and 5 shows that the bimodality found in the measurements of Koshut is still present in these measurements.

1C. Fractal Algorithms

Our initial work in this interesting new area of mathematical physics concerned the calculation of 'cycles' as presented by Peters (1994). Instead of using a fourier analysis to search for periodic cycles, we used an R/S analysis to search for non-periodic cycles. This type of cyclical behavior is often seen in chaotic phenomena. While we did find evidence for cycles in several profiles, our tests have not been exhaustive enough to reach confident conclusions. Our preliminary results were presented in Yan and Lestrade (1995).

5. Bibliography.

Eadie, W. T., D. Drijard, F. E. James, M. Roos, and B. Sadoulet, (1973) *Statistical Methods in Experimental Physics*, No. Holland Publ., N. Y., 263.

Lestrade, J. P., (1994) A New Variability Parameter for Gamma-Ray Burst Time Profiles, *Astrop. J.*, **L429**, 5-8.

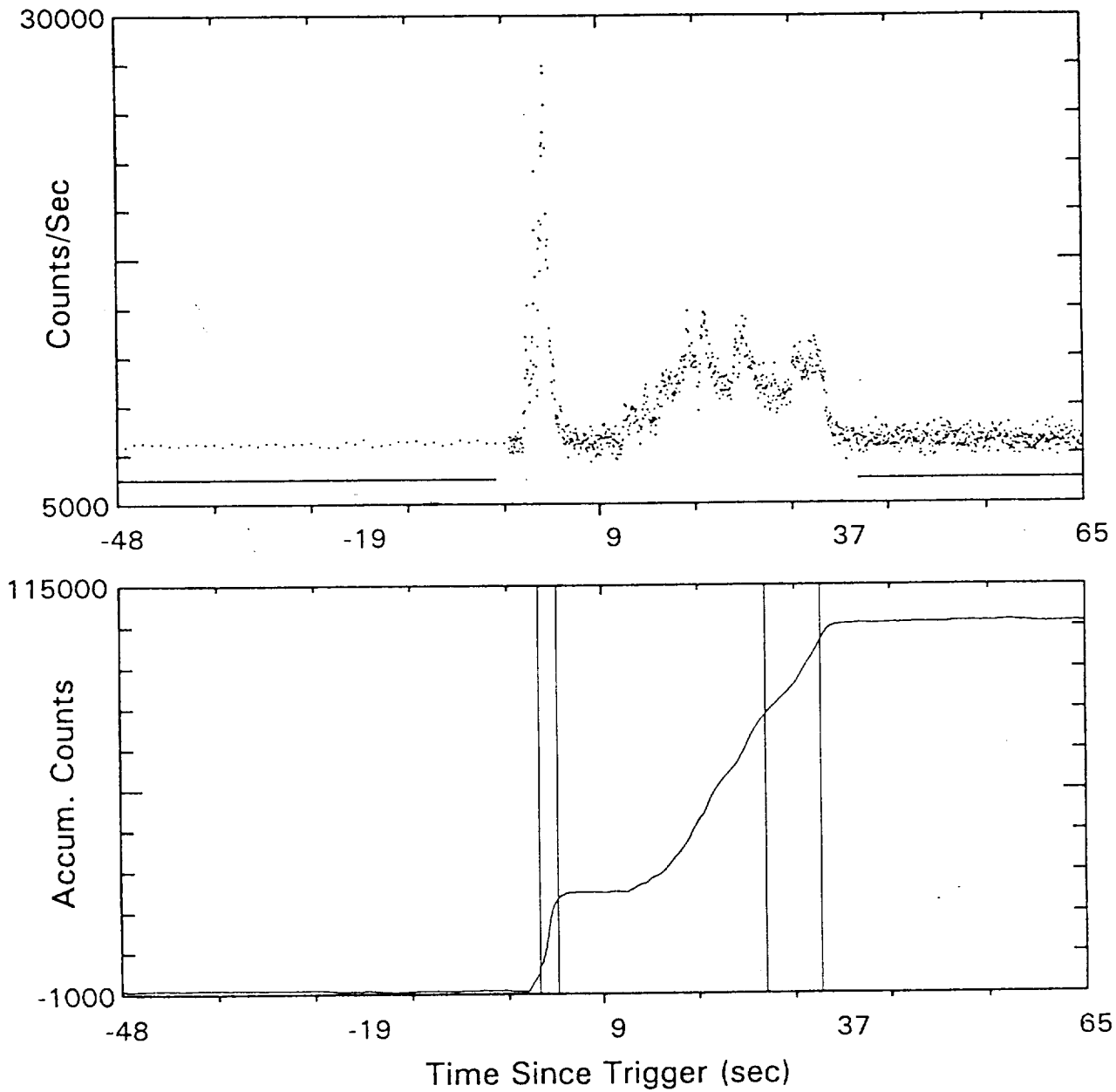
Peters, E., (1994) *Fractal Market Analysis*, (New York: John Wiley and Sons).

Yan, Yuan and J. P. Lestrade, (1994) Cosmic Gamma-Ray Burst Time Profiles: A Search for Cycles, *Proc. Miss. Acad. of Sciences*, **XXXX**, Feb. 9, 1995, p. 76.

Table I: GRB's with measured durations.

2232	2233	2240	2244	2252	2253	2254	2265
2267	2268	2273	2276	2277	2279	2283	2287
2288	2291	2298	2304	2306	2309	2310	2311
2312	2315	2316	2317	2320	2321	2324	2325
2326	2327	2328	2329	2330	2332	2340	2344
2345	2346	2347	2349	2352	2353	2357	2358
2360	2362	2365	2367	2368	2371	2372	2373
2375	2377	2380	2381	2382	2383	2384	2385
2387	2389	2391	2392	2393	2394	2395	2401
2405	2407	2408	2412	2419	2423	2424	2428
2429	2430	2431	2436	2437	2438	2440	2441
2442	2443	2446	2447	2448	2449	2450	2451
2452	2453	2454	2458	2460	2464	2472	2476
2477	2481	2482	2483	2484	2485	2487	2495
2500	2502	2505	2507	2508	2509	2510	2511
2512	2513	2514	2515	2519	2522	2523	2528
2530	2533	2536	2537	2541	2542	2551	2560
2569	2570	2571	2581	2585	2586	2589	2592
2593	2597	2599	2600	2603	2606	2608	2610
2611	2614	2615	2616	2620	2623	2628	2632
2633	2634	2636	2640	2641	2649	2660	2662
2663	2664	2665	2671	2677	2679	2680	2681
2688	2690	2691	2693	2695	2696	2697	2700
2701	2703	2706	2709	2711	2715	2719	2725
2727	2728	2736	2748	2749	2750	2751	2753
2755	2760	2767	2770	2774	2775	2776	2780
2787	2788	2790	2793	2795	2797	2798	2799
2800	2801	2810	2812	2814	2815	2819	2821
2823	2825	2828	2830	2831	2834	2843	2844
2846	2848	2849	2850	2851	2852	2853	2855
2856	2857	2860	2861	2862	2863	2864	2873
2877	2879	2880	2887	2889	2890	2891	2892
2893	2894	2896	2897	2898	2900	2901	2910
2913	2915	2916	2917	2918	2919	2922	2924
2925	2927	2929	2931	2932	2944	2945	2947
2948	2950	2951	2952	2953	2958	2961	2964
2966	2973	2974	2975	2976	2977	2978	2980
2984	2985	2986	2988	2990	2992	2993	2994
2995	2996	2998	3001	3003	3005	3011	3012
3015	3016	3017	3026	3027	3028	3029	3030
3032	3035	3036	3037	3038	3039	3040	3042
3043	3045	3046	3051	3055	3056	3057	3066
3067	3068	3070	3072	3073	3074	3075	3076
3078	3080	3084	3085	3087	3088	3089	3091
3093	3094	3096	3099	3100	3101	3102	3103
3105	3109	3110	3113	3114	3115	3118	3119
3120	3121	3127	3128	3129	3130	3131	3132
3134	3135	3136	3137	3138	3139	3141	3142
3143	3144	3146	3152	3153	3155	3156	3159
3160	3164	3166	3167	3168	3171	3173	3174
3177	3178	3193					

LPS_2436.



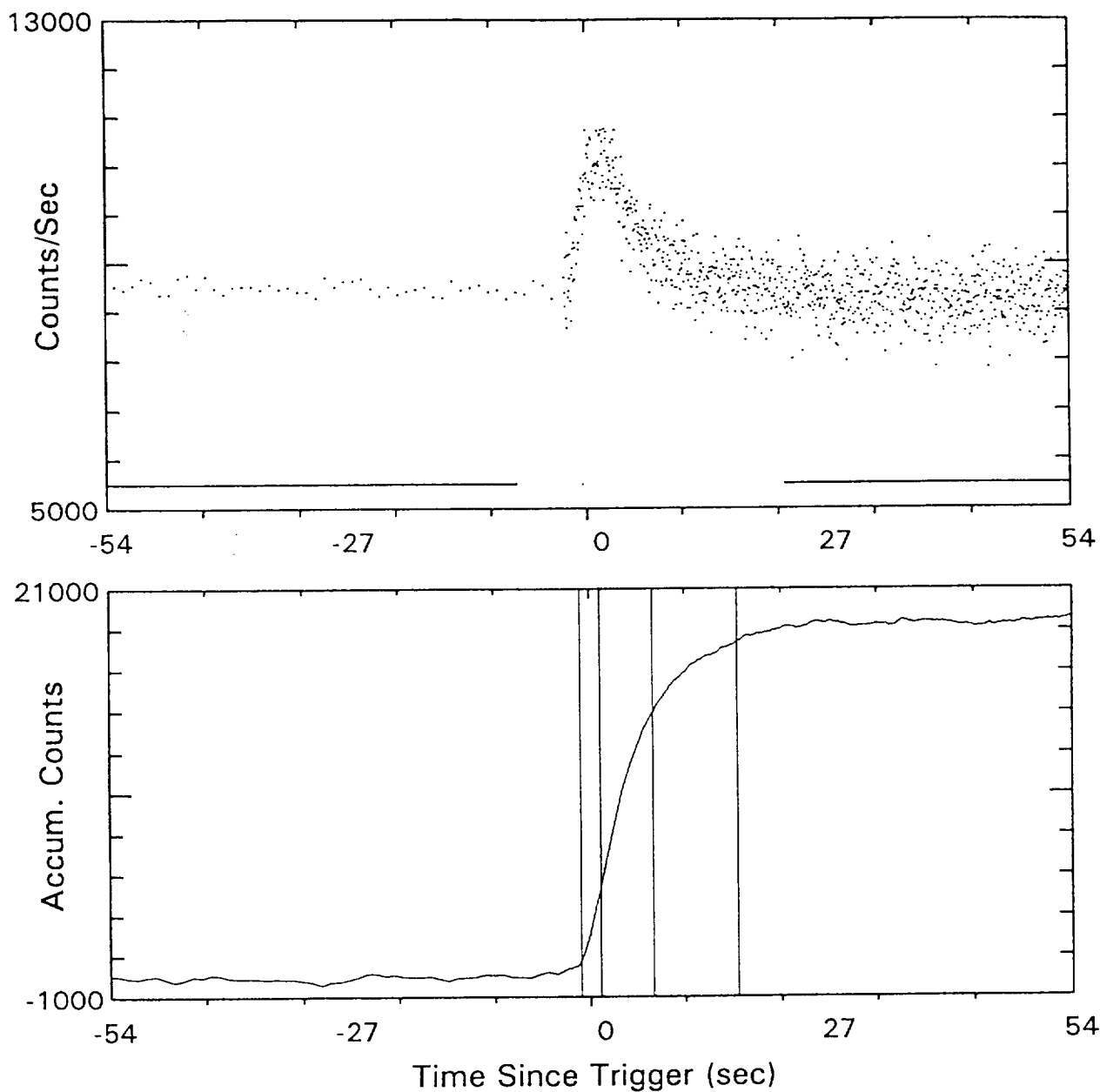
Bkgs = -47.62 to -3.58 39.01 to 65.06 0 to 0
 Poly. Order = 2; Chisq = 74; (92, 118). Coefs below:
 8151 1.663E+00 -1.214E-02 0.000E+00 0.00E+00
 Start T₅₀ = 3.36s; T₅₀ = 24.45s. +/- 0.18
 Start T₉₀ = 1.18s; T₉₀ = 33.15s. +/- 0.18

FI50 =	11,282	17,718	20,904	2,933
FI90 =	19,117	30,752	39,302	5,481

10-26-1994 11:02 lps_2436.

Figure 1

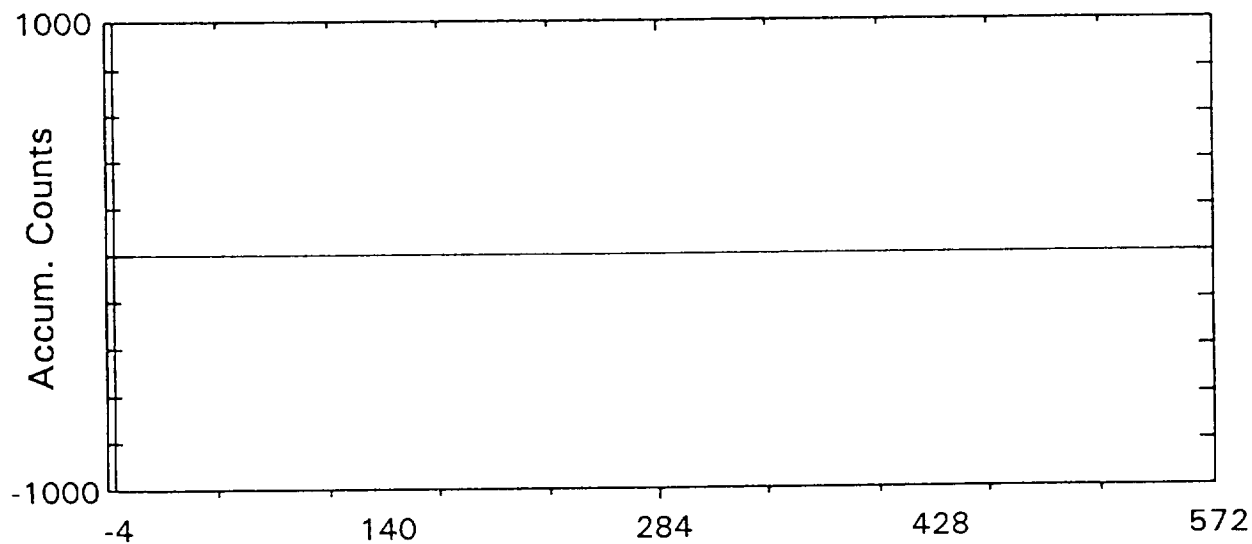
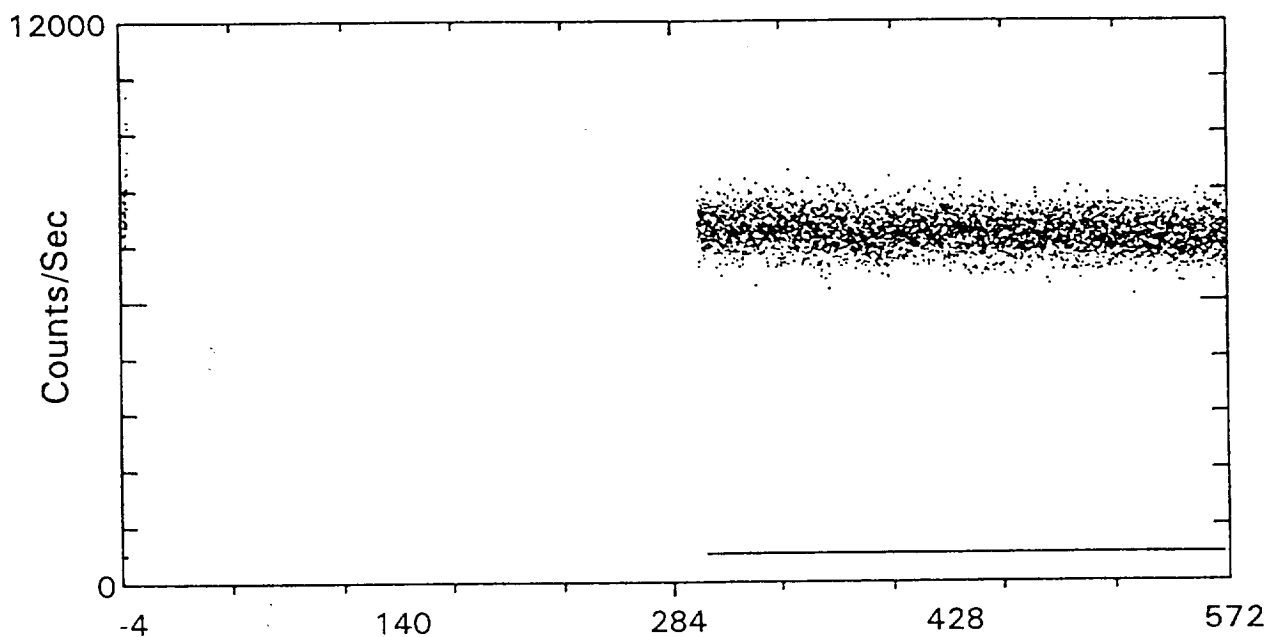
LPS_2560.



Bkgs = -53.504 to -7.424 22.688 to 54.368 0 to 0
 Poly. Order = 2; Chisq = 84; (84, 88). Coefs below:
 8511 -2.875E+00 4.525E-03 0.000E+00 0.00E+00
 Start T₅₀ = 1.632s; T₅₀ = 6.016s. +/- 0.29
 Start T₉₀ = -.608s; T₉₀ = 17.728s. +/- 0.73
 FI50 = 1,961 2,988 4,201 556
 FI90 = 3,422 5,535 7,507 1,096
 10-27-1994 10:13 lps_2560.

Figure 2

LPS_2290.



Time Since Trigger (sec)

Bkgs = -4 to -2 -2 to -1 302 to 570

Poly. Order = 0; Chisq = 0; (19, 20). Coefs below:

0 0.000 0.000E+00 0.00E+00 0.00E+00

Start T₅₀ = .096s; T₅₀ = 0s. +/- 0.181

Start T₉₀ = -.096s; T₉₀ = 0s. +/- 0.181

FI50 = 0 0 0 0

FI90 = 0 0 0 0

11-29-1994 16:42 lps_2290.

Figure 3

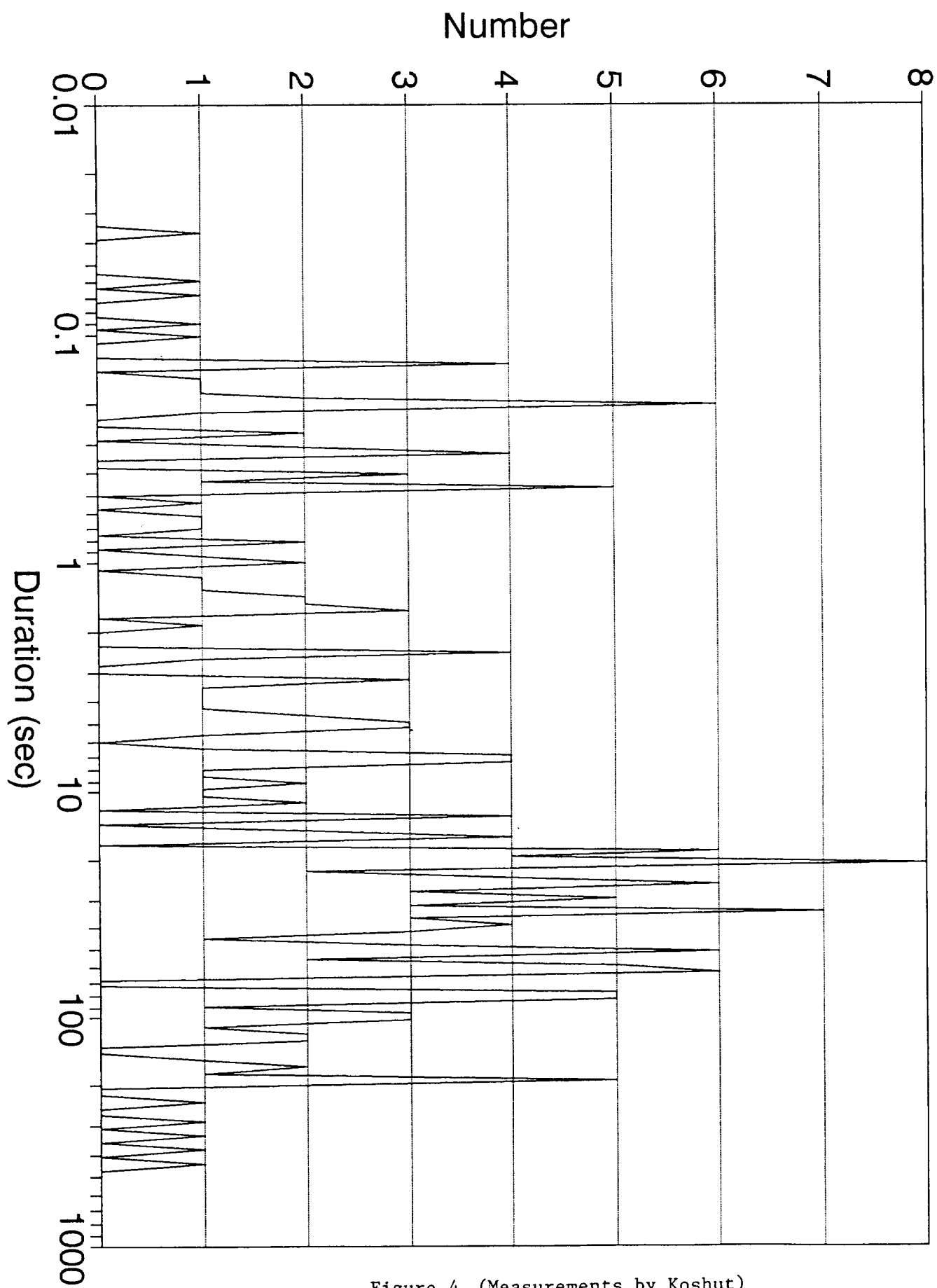


Figure 4 (Measurements by Koshut)

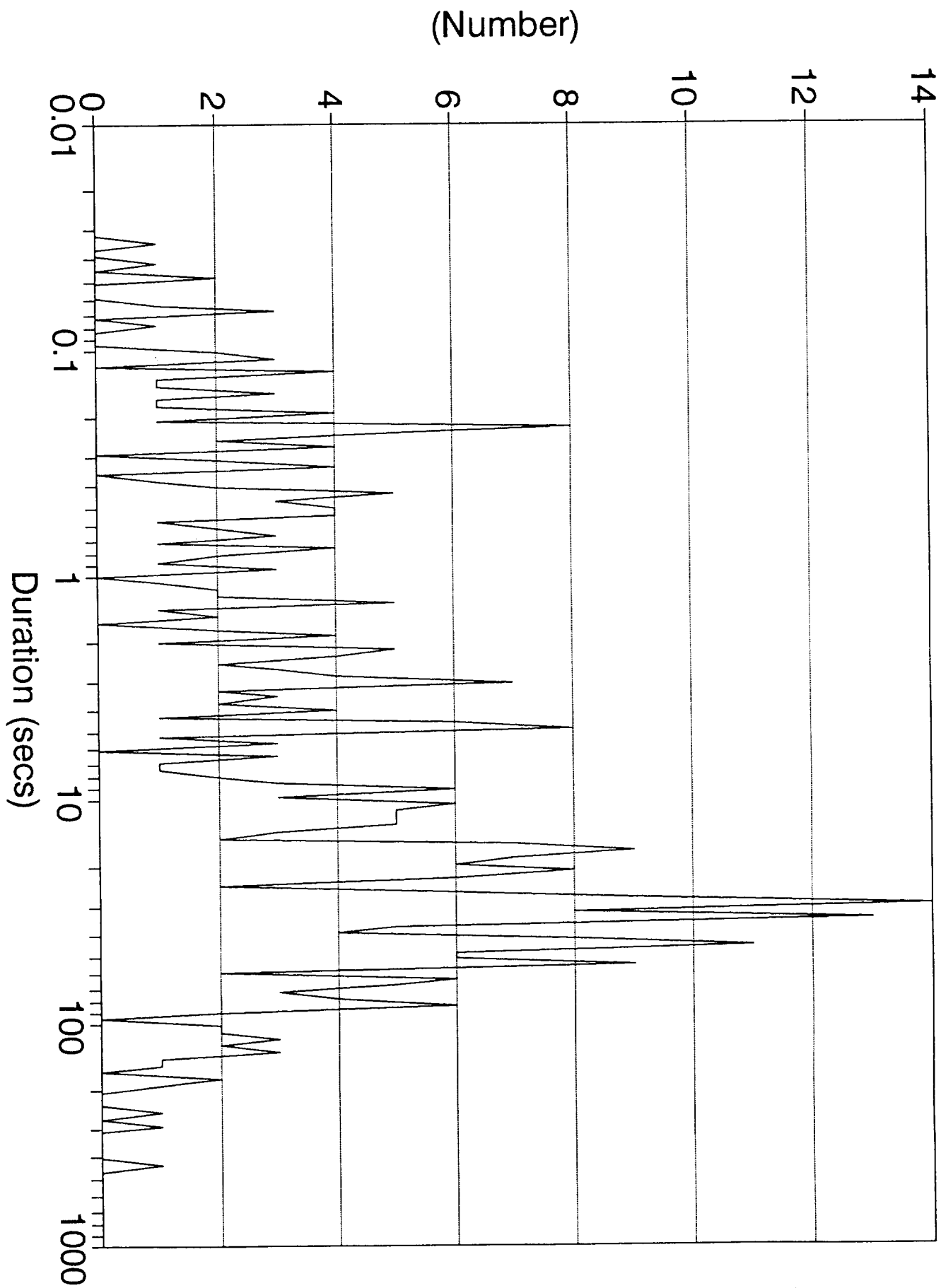


Figure 5 (Measurements by Lestrade)